1 July 1971

Materiel Test Procedure 4-2-013
Aberdeen Proving Ground

U.S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

RECOILLESS RIFLE AMMUNITION

1. OBJECTIVE

This MTP provides guidance in the writing of test plans for recoilless rifle ammunition to assure compliance with MN's, TC's, etc. From the tests listed, the test director can select those that will satisfy the requirements not only for engineering tests but for other types of proving ground testing.

2. BACKGROUND

The most desirable feature of a recoilless rifle system is its high ratio of firepower to launcher weight. The recoilless rifle makes it possible for front-line troops to launch direct-fire projectiles from a very lightweight launcher that has eliminated the cumbersome mount and recoil system formerly required. Recoilless rifle cartridges are specially designed with openings in the cartridge case to allow for the escape of gas to the rear of the weapon to counteract recoil.

Recoilless rifle ammunition, typical examples of which are shown in Figure 1, is issued as a fixed round consisting of the following components:

a. Projectile - While the recoilless rifle systems are primarily for antitank purposes, antipersonnel capabilities have also been included. The projectile design is similar to artillery applications. With HEAT projectiles a fin-stabilized projectile with low spin is used. Fixed and folding fins are both used. Pre-engraved rotating bands or plastic bands are used to minimize engraving forces and pressure buildup during "shot-start".

b. Cartridge Case - The cartridge case is of steel or aluminum and contains either circular perforations in the sidewalls or a rupture disc in the base to allow the gas to escape. A liner of cloth, paper, plastic, or a combination of rayon and plastic inside of the cartridge case protects and retains the propellant.

c. Propellant - The propellant consists of a fast burning type of M26 formulation.

d. Primer - Percussion primers are used.

To date recoilless rifle ammunition has been produced in 57-mm, 90-mm, 105-mm, and 106-mm sizes. Further details on recoilless rifle ammunition are found in TM 9-1300-203.

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13. ABSTRACT

This MTP provides guidance for planning engineering tests of recoilless rifle ammunition. It outlines test phases to be included and points out important features to be considered for each phase. The procedures apply to other types of proving ground tests of recoilless rifle ammunition as well as engineering tests.

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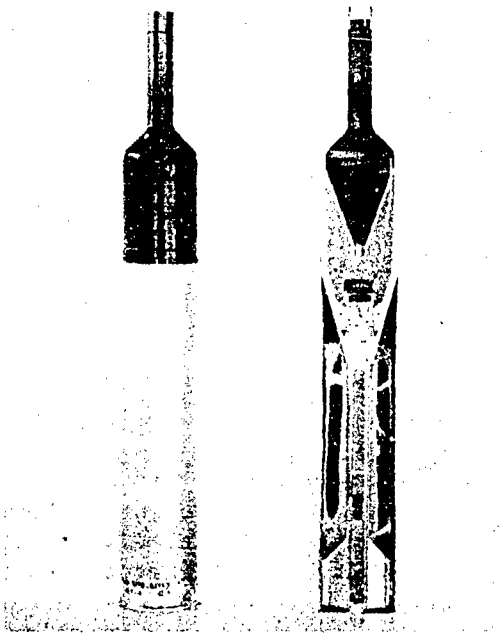


Complete Round

Weight	(approx) 9.15 lb
Length	27.75 in.
Muzzle velocity	700 fps
Maximum effective range	500 yd

Projectile

Model	M371E1
Weight as fired	6.70 lb
Length as fired	27.75 in.
Width of rotating band	0.245 in.
Method of stabilization	fin
Rate of spin	12 rps
Explosive charge	1.72 lb Composition B
Shaped charge liner	copper 42° angle

Cartridge Case

Model	M112
Material	anodized aluminum
Blowout disc	plastic
Length	16.29 in.

Primer, Percussion (500 gr) M92

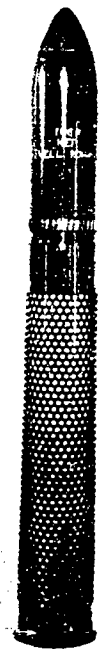
Propellant

Type and model	SP, M5, approx 0.021-in. web contained in silk or rayon bag on projectile boom
Weight of propelling charge	20 oz (approx)

Fuze

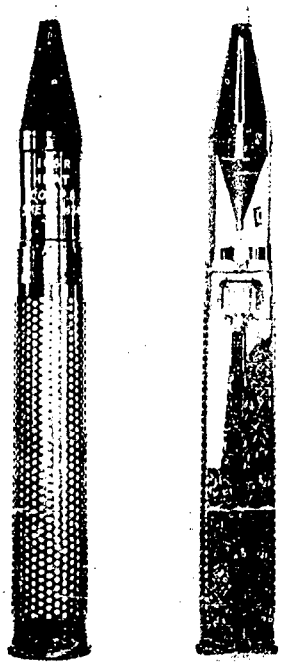
Type and model	PIBD, M530A1
Weight	0.31 lb

Figure 1. Typical Recoilless Rifle Cartridges: a - Cartridge, HEAT-FS, 90-mm, M371E1.



Complete Round	
Weight	37.93 lb
Length	38.1 in.
Muzzle velocity	1635 fps
Maximum effective range	1000 yd
Projectile	
Type and model	HEP-T, M346A1
Weight as fired	17.54 lb
Length	15.90 in.
Explosive charge	7.72 lb Composition A3
Method of stabilization	spin
Rate of spin	200 rps (approx)
Width of rotating band (pre-engraved copper)	0.20 in.
Tracer	M5
Cartridge Case	
Model	M94B1
Material	steel
Liner	inner rayon; outer polyethylene
Plastic insert in base of case	12 cu in.
Primer, Percussion (1000 gr)	M57
Propellant	
Type and model	MP, M26 (T28), approx 0.038-in. web
Weight of propelling charge	126 oz (approx)
Fuze	
Type and model	BD, M91A1
Weight	1.40 lb

Figure 1. Typical Recoilless Rifle Cartridges (Cont): b - Cartridge, HEP-T, 106-mm, M346A1.



Complete Round

Weight	36.19 lb
Length	39.31 in.
Muzzle velocity	1650 fps
Maximum effective range	1000 yd

Projectile

Type and model	HEAT, M344A1
Weight as fired	17.55 lb
Length	
Fins closed	26.50 in.
Fins open	24.25 in.
Explosive charge	2.79 lb Composition B
Shaped charge liner	copper 42° angle
Method of stabilization	fin

Cartridge Case

Model	M94B1
Material	steel
Liner	(rayon-polyethylene laminate) M6

Primer, Percussion (1000 gr) M57

Propellant

Type and model	MP, M26 (T28), approx 0.038-in. web
Weight of propelling charge	127 oz (approx)

Fuze

Type and model	PIBD, M509
Weight	0.31 lb

Figure 1. Typical Recoilless Rifle Cartridges (Cont): c - Cartridge, HEAT, 106-mm, M344A1.

Sometimes recoilless rifles employ an attached spotting rifle of 20-mm caliber or less that has ballistic flight characteristics similar to those of the major caliber projectile. The spotter is fired before firing the recoilless rifle (major caliber) to assure proper range and lead setting without giving away one's position.

When a recoilless rifle is fired, a tremendous backblast is produced (from gases escaping to compensate for lack of recoil). This backblast introduces a noise and safety problem which is unique to recoilless rifles (Fig. 2).

3. REQUIRED EQUIPMENT

Covered by the referenced MTP's.

4. REFERENCES

A. AR 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions.
B. AR 750-6, Maintenance Support Planning.
C. TM 9-1300-203, Artillery Ammunition.
D. USAMC Regulation 385-100, Safety: Safety Manual.
E. USAMC Regulation 700-34, Release of Materiel for Issue.
F. USATECOM Regulation 70-23, Equipment Performance Reports (EPR's).
G. USATECOM Regulation 70-24, Documenting Test Plans and Reports.
H. USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.
I. USATECOM Regulation 705-1, Materiel Testing Coordination and Relationships.
J. USATECOM Regulation 705-16, Format of USATECOM Plans of Test.
K. USATECOM Regulation 750-15, Maintenance Evaluation During Testing.
L. MIL-STD-331, Fuze and Fuze Components, Environmental and Performance Tests for.
M. MIL-STD-810B, Environmental Test Methods.
N. Dutschke, W., Final Report on Engineering Test of Cartridge, 106-mm, Antipersonnel, XM581 with Fuze, MT, XM592E1, for Use with 106-mm M49A1 Recoilless Rifle, Aberdeen Proving Ground, Report DPS-3052, February 1969.
O. Dutschke, W., Final Report on Engineering Test of Cartridge, 90-mm, Canister, Antipersonnel, XM590E1 for Use in Rifle, Recoilless 90-mm, M67, Aberdeen Proving Ground, Report DPS-2578, November 1967.
P. Binomial Reliability Table (Lower Confidence Limits for the Binomial Distribution), U. S. Naval Ordnance Test Station, China Lake, Calif., DDC No. AD 444 344.
Q. MTP 2-2-815, Rain and Freezing Rain.
R. MTP 3-1-002, Confidence Intervals and Sample Size.

Figure 2. Test Setup for Measuring Overpressure with 90-mm Recoilless Rifle M67.

S. MTP 3-1-004, Artillery Range and Ballistic Match Firings (Indirect Fire).
T. MTP 3-2-066, Recoilless Weapons.
U. MTP 3-2-807, Materials Testing - Nondestructive Examination.
V. MTP 3-2-810, Weapon Pressure Instrumentation.
W. MTP 3-2-811, Noise and Blast Measurements.
X. MTP 4-1-001, Testing Ammunition and Explosives.
Y. MTP 4-2-055, Fuzes.
Z. MTP 4-2-500, Ammunition Characteristics.
AA. MTP 4-2-504, Safety Evaluation - Artillery, Mortar, and Recoilless Rifle Ammunition.
AB. MTP 4-2-601, Drop Tower Tests for Munitions.
AC. MTP 4-2-602, Rough Handling Tests.
AD. MTP 4-2-605, Ballistic Matching of Major and Minor Caliber Systems.
AE. MTP 4-2-800, Physical Measurement of Projectiles.
AF. MTP 4-2-804, Laboratory Vibration Tests.
AG. MTP 4-2-805, Projectile Velocity Measurements.
AH. MTP 4-2-806, Impact Sensitivity of Fuzes.
AI. MTP 4-2-812, Penetration as a Function of Spin Rate for Fin-Stabilized, Shaped Charge Projectiles (Static Test).
AJ. MTP 4-2-813, Arena Test of HE Fragmentation Munitions.
AK. MTP 4-2-818, Testing for Fungus Resistance.
AL. MTP 4-2-819, Sand and Dust Testing of Ammunition.
AM. MTP 4-2-820, Humidity Tests.
AN. MTP 4-2-822, Airblast Pressure Measurement - Electronic.
AO. MTP 4-2-823, Paper Blastmeters.
AP. MTP 4-2-826, Solar Radiation Tests.
AQ. MTP 4-2-827, Time of Flight and Ballistic Coefficient.
AR. MTP 4-2-829, Vertical Target Accuracy and Dispersion.

5. SCOPE

5.1 SUMMARY

This MTP outlines the test phases that should be considered in the planning of a test for recoilless rifle ammunition. Although the procedures are designed for engineering tests, they are also applicable to other types of proving ground testing. The following test phases are included:

Safety Evaluation (para 6.2.1)
Accuracy (para 6.2.2)
Reliability (para 6.2.3)
Lethality (para 6.2.4)
Plate Penetration (para 6.2.5)
Environmental Tests (para 6.2.6)
Human Factors (para 6.2.7)
Maintenance Evaluation (para 6.2.8)
Weapon Calibration (para 6.2.9)

5.2 LIMITATIONS

This pamphlet does not cover service tests (MTP 4-3-xxx series), field environmental tests (MTP 4-4-xxx series), or tests pertaining to nuclear type warheads.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Review of Test Guidance

The subtests that are selected by the test agency are governed by MN's, TC's, and test directives from supervising agencies. Acceptable performance levels are usually stipulated. If adequate test guidance is not furnished, the test plan writer consults the responsible USATECOM directorate who, in turn, consults the appropriate commodity command or CDC agency when an MN does not exist.

MN's may not be specific regarding certain important features such as lethality, smoke, flash, blast overpressures or noise measurements, cook-off, misfire removal, and tracer burning times. In such instances the procedures in appropriate MTP's are followed, and results are compared with general standards that have been established or with the performance of standard items.

6.1.2 Safe Operations During Testing

All hazardous test operations must be covered by a local standing operating procedure (SOP) that provides compulsory safety measures to be followed. Some typical operations that are classified hazardous are: misfire removal, rapid-fire tests, and tests requiring defined blast danger areas. Safety measures for routine operations are prescribed in the USAMC Safety Manual (Ref. 4D). The safety statement furnished by the developer is reviewed for any unusual requirements.

The test plan will specify any special safety precautions and provide guidance for the writing of an SOP for safely conducting the test.

6.1.3 Sequence of Testing

The sequence of testing - i.e., the order in which subtests are conducted - is dependent upon the type of test and availability of supporting equipment. The safety evaluation takes precedence, and subtests to complete this requirement are conducted before the others. Subtests that are expected to reveal item unsuitability should be performed next so that time and money are not needlessly spent on an item destined to fail. If such "high-risk" tests are not defined in the test plan, a review of prior test results may indicate which subtests will apply. After these requirements, other subtests should be performed in the most economical sequence feasible.

6.1.4 Sample Size

The establishment of adequate sample sizes is one of the most difficult problems in the testing of ammunition - particularly since most of the tests are destructive and the test items are from limited development samples. Maximum use of statistical techniques is made to assure that sample sizes will be adequate to support conclusions as to the suitability of the item. When the requirements cite reliability criteria and confidence levels, sample sizes will be computed to assure that such levels are met. If the number of samples available is not sufficient to meet the stated requirements, the test plan will indicate the confidence level attainable with the samples available. A statement will also be included to show the number that would be required to fully meet the stated requirements. Guidance in selecting samples for desired confidence levels is contained in MTP 3-1-002. To assure a correct interpretation of the reliability statement, which is often complex, the test plan writer should consult with someone who specializes in reliability.

6.1.5 Initial Inspection and Characteristics

An initial inspection is conducted to assure that the ammunition is not damaged. Characteristics data (MTP 4-2-500) on the ammunition and ammunition components are collected at the same time to assure that the materiel complies with the military specifications. A characteristics data sheet, consisting of a general or exploded view photograph and a tabulation of the important features of the test item, is assembled. The ammunition is identified by comparison with the producer's data card. If the samples have not been numbered, sample numbers are assigned to them prior to testing.

At this time the maintenance test package (AR 750-6) is checked for completeness, and an Equipment Performance Report (EPR) listing any missing items is submitted to the commodity command, with a copy to USATECOM. Testing will not be started until the items are received or a waiver is furnished by USAMC.

6.2 TEST CONDUCT

6.2.1 Safety Evaluation

Recoilless rifle systems involve the same safety problems as conventional artillery systems plus the problems of breech overpressure and backblast. The basic guide for tests leading to a safety release of ammunition is MTP 4-2-504. Included in this procedure are requirements for sequential rough handling (MTP 4-2-602), drop tests (MTP 4-2-601), laboratory vibration tests (MTP 4-2-804), and humidity tests (MTP 4-2-820). Fuze arming tests to establish the minimum arming distance and impact sensitivity tests (MTP 4-2-806) are conducted as part of the safety evaluation. Rate of fire and cook-off tests (MTP 3-2-066), though not a specific requirement for the safety evaluation, are an adjunct to the overall evaluation.

6.2.2 Accuracy

The ammunition is fired for accuracy and dispersion from the appropriate weapon on a special mount that will minimize errors other than those attributable to the ammunition. For direct-fire systems the target is located at the maximum effective range, and the procedures of MTP 4-2-829 are followed. Time of flight is measured as described in MTP 4-2-827. When spotting rifles are used, the ammunition is tested with the prescribed spotter (MTP 4-2-605). For cartridges to be used in the indirect fire mode, range firing as outlined in MTP 3-1-004 is required. Data are accumulated from these firings to determine a maximum weapon angle of elevation on level ground in a ground-mounted system.

6.2.3 Reliability

Tests must be designed so that the functioning reliability of the major components (e.g., the fuze) can be determined. This information may be required not only during the safety evaluation (6.2.1 above) but after the ammunition has been subjected to the various environments outlined in 6.2.6 below. Seldom, however, is the test item subjected to all the environmental conditions in a single test program. As stated in paragraph 6.1.4, the sample size must be consistent with the reliability criteria. The desired reliability should be stated in the MN generated by the user and transmitted to the test agency in the USATECOM directive to write the test plan. When this requirement is known, sample sizes are obtained from the Binomial Reliability Table, reference 4P. The functioning results from all the subtests are usually combined to arrive at the overall reliability of the test item.

6.2.4 Lethality

Using data from the accuracy tests (MTP 4-2-829) and fragmentation tests (MTP 4-2-813), the lethality (quantitatively referred to in terms of "lethal area") of a cartridge type is determined for antipersonnel purposes. An example of lethality evaluation for special antipersonnel rounds may be found in references 4N and O.

6.2.5 Plate Penetration

Plate penetration capabilities of a cartridge may be determined both statically (MTP 4-2-812) and dynamically. The type of plate, its mechanical properties, thickness, and obliquity with respect to the weapon and projectile are required information. Penetration and accuracy data are used to determine kill probability against armored vehicles.

6.2.6 Environmental Tests

Ammunition will experience many environments in transport, in storage, and in the field. Following (with test references) are some of the conditions that should be considered to insure that the user will be supplied with the most suitable item.

a. Sand and dust - MTP 4-2-819.
b. Salt spray - MIL-STD-810B.
c. Extreme temperatures - Usually conducted during safety evaluation. Any additional rounds fired for performance are temperature soaked and fired in accordance with the climatic categories of AR 70-38 which, when applied to ammunition, are interpreted as follows:

Climatic Category of AR 70-38	Assumed Condition of Ammunition	Test Temperature, °F
Intermediate hot-dry	Sitting in sun	145
Intermediate cold	Uncovered in open	-35
Hot-dry	Under shade	145 (from intermediate hot-dry)*
Cold	Uncovered in open	-50
Extreme cold (only when directed)	Uncovered in open	-70

*High temperature storage test (non-firing) is performed at 160°F.

d. Solar radiation - MTP 4-2-826.
e. Fungus resistance - MTP 4-2-818.
f. Temperature-altitude - MIL-STD-810B.
g. Thermal shock - MIL-STD-331.
h. Rain tests - MTP 2-2-815.
i. Immersion - MIL-STD-810B.

6.2.7 Human Factors

Human factors involved in the use of recoilless rifle ammunition are evaluated by weighing the observations made during all test phases. Following are some of the observations that should be made:

a. Any difficulty in setting the fuze, including setting while wearing arctic mittens.
b. Any excessive blast (MTP's 4-2-822, 4-2-823) resulting from firing the rounds.
c. Any difficulty in handling or loading the round.
d. Any difficulty in identifying the round during the day or night.

6.2.8 Maintenance Evaluation

Maintenance data are mandatory for engineering, service, check, and initial production tests which are performed to determine the suitability of an item for any use or release. The maintenance evaluation (USATECOM Reg. 750-15) is made to verify the maintenance and

maintainability requirements of the test item and determine the adequacy of the maintenance test package. The maintenance literature (POMM) is reviewed. Ease of handling and maintaining the test item with the minimum number of special tools provided, time required, and human factors implications (6.2.7 above) are evaluated. Any maintenance problems encountered are reported by EPR (USATECOM Reg. 70-23) and included in the test report. Particular points to be evaluated are any difficulty in setting the fuze, loading the cartridge, or sensing the target.

6.2.9 Weapon Calibration

The velocity and recoil of a recoilless rifle are affected by the dimensions and wear of the breech nozzle venturi. The condition of the weapon must be identified in all ammunition tests. When a rifle is equipped with a compensator, such as the 106-mm M206, the compensator setting must be identified. Correction factors for the effect of wear on velocity and recoil are not precise enough for most ammunition testing. This effect can be minimized by the use of calibration rounds. Calibration rounds should approximate as nearly as possible the same ammunition type as will be tested in the rifle.

6.3 TEST DATA

The data to be recorded in each test phase are indicated in the referenced MTP's. EPR's covering each failure that occurs are sent to the sponsoring agency within 72 hours following the incident. Each incident is categorized as a deficiency, shortcoming, or suggested improvement or by special designation. Distribution of the EPR is generally specified in the USATECOM test directive or the sponsor's test request. (Mandatory distribution is found in local operating procedures.)

6.4 DATA REDUCTION AND PRESENTATION

The reduction and presentation of data will be made as described in the referenced MTP's.